Voyager Bulletin

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Satellites of Uranus

Uranus' five largest satellites — Miranda, Ariel, Umbriel, Titania, and Oberon — were discovered over a period of 161 years from 1787 to 1948. Until the Voyager flyby they were no more than points of light in even the best Earth-based telescopes.

All of the best resolution observations of the Uranian satellites occurred within an 8-hour span, due to the unique tilted orientation of the planet and satellite orbits. Because so much was happening in such a short period, many of the observations were recorded on the spacecraft's digital tape recorder and played back to Earth later.

At the press conference on January 26, imaging team member Larry Soderblom, of the U.S. Geological Survey, told the media, "No one could have anticipated the exotic things I'm going to show you this morning.

"As we move closer to Uranus, we see increasing ferocity in the way these bodies have been tectonically shuffled in cataclysmic fashion, and it doesn't seem to be related to time," said Soderblom. "Sandwiched between some very active objects is an object that is very dark and inactive (Umbriel). We don't know why."

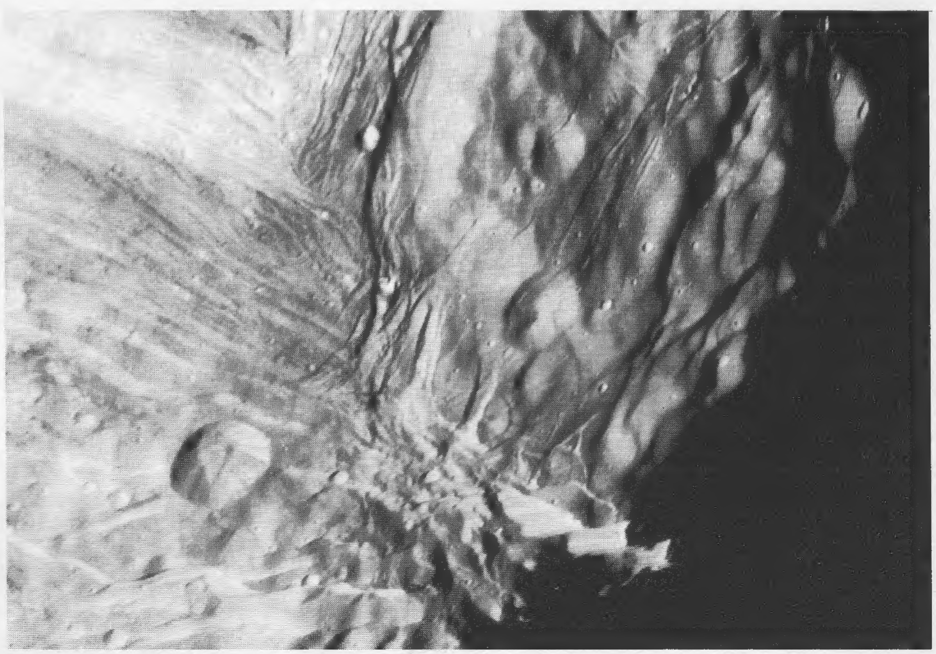
Umbriel is an enigma in the solar system because it is so gray and bland. It orbits between two pairs of satellites that show much geologic history, yet it itself is dark and shows little contrast. It may be the oldest satellite surface in the Uranian system. A white donut-shaped patch near the north pole is 30 percent brighter than most of Umbriel and may be material in the floor of a 150-km diameter crater. Umbriel also has several overlapping large craters, with diameters from 100 to 200 km.

Oberon has many craters, which probably formed more recently than the period of meteoroid bombardment throughout the solar system nearly 2.5 million years ago. Material in the crater floors looks as though it were deposited sometime even later than the crater formation. Oberon also has a large mountain, rising nearly 6 km (4 mi) above the surface.

Internal processes must be at work on Titania, where bright frost-like material appears to be leaking out of the interior through graben-like features caused by crustal faulting.

Ariel, the brightest of the large moons, shows evidence of a great deal of geologic activity in the past. Fracture patterns, deep incisions into the surface, may be tensional fault systems. These valley floors appear to be filled by a single continuous flow of material. Other valleys are more sinuous and may have been caused by fluid flow or sublimation. One image shows three linear features, which look remarkably like the flow of an ice mass, such as a glacier on Earth. Any such process must have occurred some time ago, however, since the large numbers of craters overlying this feature indicate that it is quite old.

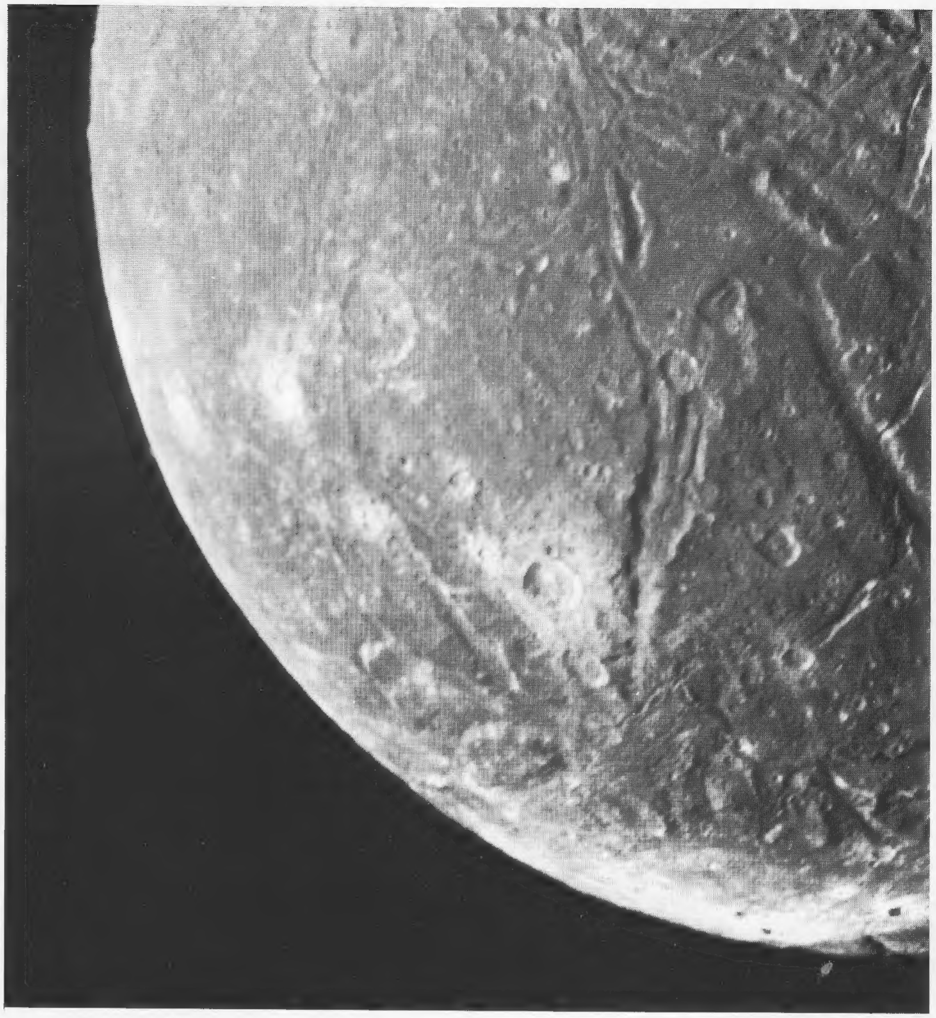
Miranda

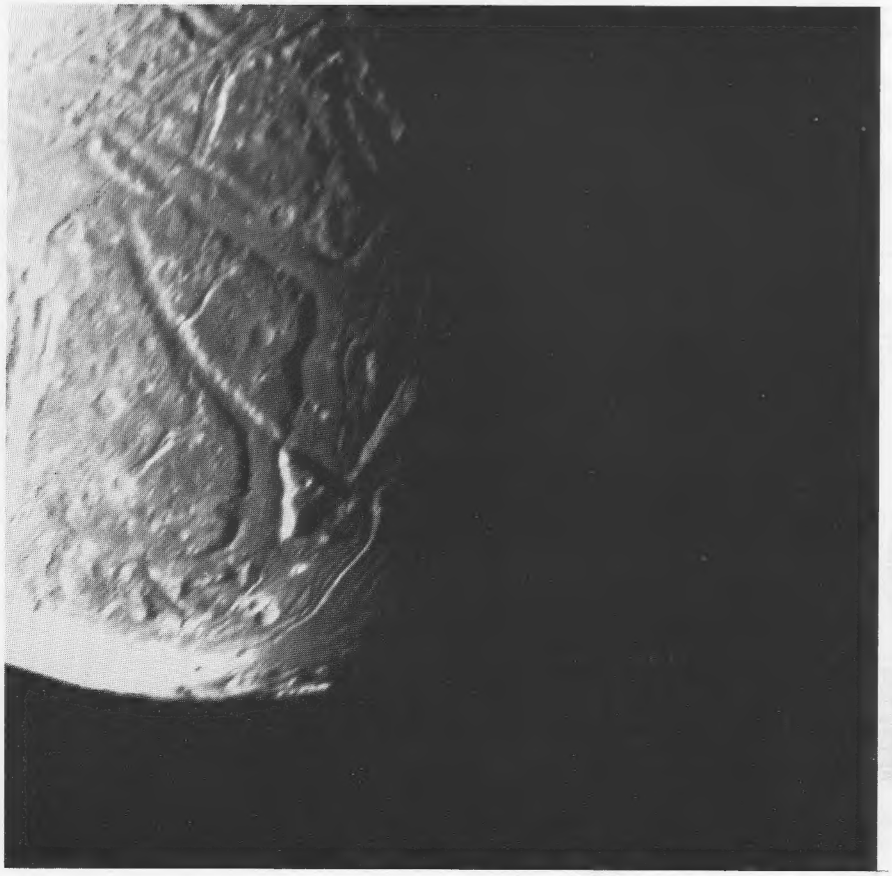


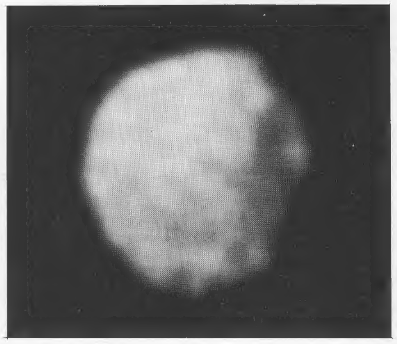
Sunlight reflects dramatically from cliff faces which drop abruptly from higher, older, cratered terrain to lower, striated elevations on Miranda. The precipice may be 5 km (3 mi) deep. Sinuous scarps, probably caused by faulting rather than erosion, cut across both terrains. The impact crater at lower center in this image is about 25 km (15 mi) across. This clear-filter, narrow-angle image shows an area about 250 km (150 mi) across, at a resolution of about 800 meters (2,600 feet) and was taken January 24, 1986 from 36,000 km (22,000 mi).

Ariel

The complexity of Ariel's surface indicates that a variety of geologic processes have occurred. The numerous craters, for example, are indications of an old surface bombarded by meteoroids over a long period. Also conspicuous at this resolution, about 2.4 km (1.5 mi), are linear grooves (evidence of tectonic activity that has broken up the surface) and smooth patches (indicative of deposition of material). Below, the highest-resolution view of Ariel's terminator shows a complex array of transecting valleys with superimposed impact craters. Particularly striking is the fact that the faults that bound the linear valleys are not visible where they transect one another across the valleys. Apparently these valleys were filled with deposits sometime after they were formed by tectonic processes, leaving them flat and smooth. Sinuous rilles (trenches) later formed, probably by some flow process. Some type of fluid flow may well have been involved in their evolution. These clear-filter, narrow-angle images were taken on January 24, 1986, from a distance of 130,000 km (80,000 mi).

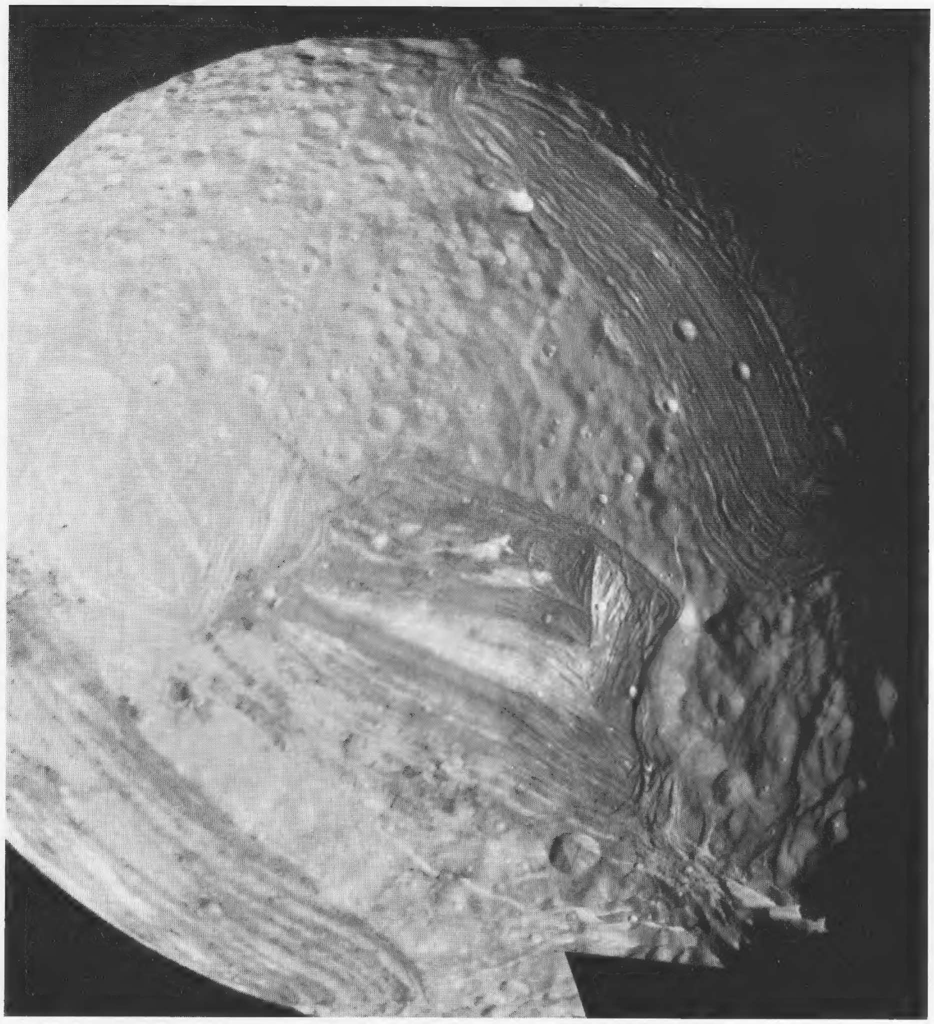




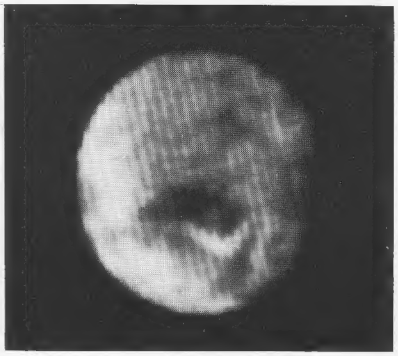


1985U1

Several craters are seen on the surface of 1985U1, one of several small moons of Uranus discovered by Voyager 2. With a diameter of about 150 km (90 mi), 1985U1 appears as a dark, nearly spherical object; the dark surface reflects only 7 percent of the incident light. The spacecraft acquired this single image—the only close-up it obtained of any of the new moons—on January 24, 1986. At the time, Voyager was about 500,000 km (300,000 mi) from 1985U1, yielding a resolution of about 10 km (6 mi) in this clear-filter, narrow-angle image.



Miranda



Miranda, roughly 500 km (300 mi) in diameter, exhibits varied geologic provinces, seen in this computer-assembled mosaic (left) of images taken January 24, 1986. The images were obtained from distances of 30,160 to 40,310 km (18,730 to 25,030 mi); resolution ranges from 560 to 740 meters (1,840 to 2,430 feet). Without the target motion compensation technique devised by this Voyager flight team, the top image, with a resolution of about 26 km (16 mi), would have been the best resolution obtained at Miranda. This technique allows the spacecraft to drift at a controlled rate to track the target body and reduce image smear caused by high relative velocities between the spacecraft and the target. These are among the highest-resolution pictures that Voyager has obtained of any of the new "worlds" it has encountered during its mission. The missing piece of Miranda's surface will be included in a later mosaic once more complicated computer processing can be completed.

Umbriel

Umbriel is the darkest of Uranus' larger moons and the one that appears to have experienced the lowest level of geological activity. The southern hemisphere of the moon displays heavy cratering. Umbriel has a diameter of about 1,200 km (750 mi) and reflects only 16 percent of the light striking its surface; in the latter respect, it is similar to lunar highland areas. Umbriel is heavily cratered but lacks the numerous bright-ray craters seen on the other large Uranian satellites; this results in a relatively uniform surface albedo (reflectivity). The prominent crater on the terminator (the day-night boundary, right) is about 110 km (70 mi) across and has a bright central peak. The strangest feature in this image is a curious bright ring (at top), the most reflective area seen on Umbriel. The ring is about 140 km (90 mi) in diameter and lies near the satellite's equator. The nature of the ring is not known, although it might be a frost deposit, perhaps associated with an impact crater. Spots against the black background are due to "noise" in the data. Voyager 2 took this image on January 24, 1986, from a distance of 557,000 km (346,000 mi). This frame, taken through the clear filter of Voyager's narrow-angle camera, is the most detailed image of Umbriel, with a resolution of about 10 km (6 mi).

	RING WIDTH (km)	BODY DIA. (km)	ORBITAL DISTANCE (km)
URANUS		25,600	
1986U2R	3000		39,000
RING 6	1		41,877
RING 5	1		42,275
RING 4	1		42,610
alpha	8		44,758
beta	8		45,701
eta	1		47,215
gamma	2		47,666
delta	6		48,339
1986U7		30	49,300
1986U1R	3		50,000
epsilon	58		51,188
1986U8		20	53,300
1986U9		60	59,100
1986U3		70	61,750
1986U6		50	62,700
1986U2		70	64,350
1986U1		90	66,090
1986U4		50	69,920
1986U5		50	75,100
1985U1		170	85,982
Miranda		480	129,783
Ariel		1170	191,239
Umbriel		1190	265,969
Titania		1590	435,844
Oberon		1550	582,596

Miranda, smallest and innermost of the large satellites, is the most bizarre, with scarps, sawtooth terraces, extensional and compressional faults, cratering, slabs, and trenches. Planetary geologists studying Miranda's geomorphology — geologic shapes — plan to use Voyager images to construct three-dimensional models of Miranda using stereogrammetry. Most of the terraces are on the Uranus-facing hemisphere. Miranda is a slightly warm object with a reddish cast. Different colors may indicate different materials or processes.

Dr. Soderblom presented a possible model for Miranda's evolution, in which loose material accreted, differentiated, fragmented, and then reaccreted. He also suggested that the chevron, "racetrack"-like features, and open trenches are all steps in the evolution of features on Miranda's surface.

Early analysis suggests that the darkness of the satellites' surfaces may be caused by radiative damage from Uranus' radiation belts, where ions impacting methane ice on the surface breaks the ice into hydrogen and carbon and the hydrogen is driven off into space by fast protons, leaving the dark carbon behind. Cosmic ray investigators have calculated that in 100 years, 100 trillion protons would hit the satellite surfaces, leaving a dark residue.

As anticipated, Voyager 2 discovered many small satellites in and near the rings of Uranus, but no new large objects were found.

Between December 30 and January 23, ten new moons were discovered in Voyager data. These range in diameter from 20 to 170 kilometers and are very dark. Because they are so small, little more can be determined about them aside from their sizes, orbital distances, and orbital periods.

The largest of these, 1985U1, is remarkably round and has at least two craters. 1985U1 was resolved in a single Voyager image that was inserted into the observational sequences soon after the satellite was discovered at the end of December. Receipt of the image itself was a "cliffhanger" since the original playback was lost due to a few minutes of mechanical problems at the tracking station scheduled to receive it. Engineers were able to reschedule the playback without loss of other data, and the second playback was successfully received.

Two of the small satellites, 1986U7 and 1986U8, flank the epsilon ring. They are called "shepherding satellites" because they are thought to herd ring particles between them, keeping the particles in orbit around Uranus (otherwise the ring particles might escape to space or fall into the planet). Shepherding satellites were first discovered in the rings of Saturn.

The photopolarimeter experiment may have detected other small satellites in the rings. Satellites within a ring system tend to clear a path, much like the wake of a boat. Such wakes appear in the data of the photopolarimeter instrument, which measured structures in the ring system as small as a few meters across.

February 25 marks the end of the Uranus encounter period. The official summaries of the Uranus findings will be published in *Science* magazine in late May 1986.

Voyager 2 is on its way to Neptune, which it will encounter on August 25, 1989 (Universal Time) at a distance of barely 1300 kilometers (800 miles) above its cloudtops.

Neptune is about the same size as Uranus. It has an internal heat source, so the convective actions in its atmosphere should be more conducive to observing cloud features. In addition, Voyager 2 will fly about 6000 kilometers (2000 miles) from Triton, Neptune's largest satellite (slightly larger than Jupiter's Io). These dual encounters (Neptune and Triton) will be Voyager's closest flybys since launch from Earth. Triton's orbit is retrograde — in the opposite direction to most planetary motions. Triton appears to have a methane atmosphere, with liquid nitrogen on its surface.

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